

## Remarks

### *Background*

Among the stated objects of the invention (page 4 of the specification) is that of providing a system, based upon augmented FT-IR technology, that is particularly adapted for the analysis of mixed gas samples and that is relatively compact, incomplex, inexpensive and convenient to construct and employ. As broadly envisioned, the objects of the invention are, as stated, attained by the integration of one or more supplemental sensors into an FT-IR product.

The broad advantages of the augmented FT-IR analysis apparatus and method of the invention are described in the paragraph bridging pages 3 and 4 of the specification. More particularly they afford a capability for measuring infrared-inactive species without increasing overall production dimensions, without requiring the use of dried sample gases, and without unduly increasing costs, complexity, and/or response times. They also afford the ability for close coupling, with the optical cell of an FT-IR instrument, of devices for measuring infrared-inactive species. That ensures that measurements for all detectable gases are made concurrently (i.e., at least substantially simultaneously), and from the same, identical gas sample, and thus promotes utmost accuracy in the analysis and provides further significant benefits as well.

In the paragraph beginning at line 17 on page 2 of the specification, Applicants identify an important potential application for the apparatus and method of the invention, residing in the ability that they afford for quantitatively measuring the excess molecular oxygen concentration in exhaust gas, simultaneously with the combustion-generating emissions. That combustion process monitoring ability is of considerable benefit for process understanding, optimization, and control and, when hydrogen is used as a fuel, the ability to concurrently measure the concentration of molecular hydrogen significantly increases the benefits derived.

### *The Claims*

The claims of the application, as herewith presented, have been amended extensively to emphasize the features by which the instant apparatus and method achieve the stated objectives and afford the benefits described.

All apparatus claims now require the incorporation of at least one sensor that is constructed for the analysis of molecular oxygen. That sensor is enclosed within the FT-IR product case (which is specifically recited), and is integrated into structure defining a gas flow path for contact by the gas that is to be analyzed. The claims also require the radiation source, the interferometer, the gas sample cell, the detector and preamplifier, and optics (for transmitting radiation between the radiation source, the interferometer, the gas sample cell, and the detector) to be enclosed within the FT-IR gas analyzer product case.

The claimed FT-IR gas analyzer is now further defined to include a single gas inlet conduit connected to the gas sample cell for conducting gas thereto from an external location, and a single gas outlet conduit connected to the gas sample cell for conducting gas therefrom to an external location, both conduits having at least a portion of their length enclosed within the product case. The flow path for gas to be analyzed is defined to comprise the recited gas inlet conduit and gas outlet conduit, together with the gas sample cell of the FT-IR gas analyzer.

The apparatus is expressly devoid of any gas analysis means that is disposed external to the product case and operatively connected to the gas flow path. This requirement emphasizes the compactness of the claimed analysis apparatus, and the close coupling of the constituent components, which features are fundamental to the benefits that it affords.

In accordance with Claim 4, the apparatus must additionally include a second sensor that is constructed for the analysis of molecular hydrogen. That sensor is also enclosed within the FT-IR product case, and is integrated into the structure defining the flow path for contact by the gas that is to be analyzed.

The claims defining the method of the invention recite all of the features by which the apparatus is characterized. Essential requirements of the method are that it be capable of measuring the concentration of molecular oxygen, and that the sample of mixed gas that is to be analyzed be passed into contact with no gas analysis means upstream or downstream of the FT-IR gas analyzer. The method of Claim 15 requires, in accordance with a preferred embodiment, that the apparatus employed have the capability of measuring the concentration of molecular hydrogen, and Claim 23 expressly defines the sample of mixed gases to be one that is obtained from the exhaust gas of a combustion process and that contains at least one infrared-active component (see Figures 8a through 8c of the drawings, and the corresponding text).

New Claim 24 more specifically defines a method that is employed for monitoring a combustion process, again utilizing the unique apparatus of the invention but additionally reciting steps of carrying out a combustion process and obtaining samples from the gas exhaust stream, containing molecular oxygen and an infrared-active component, which samples are passed along the gas flow path through the FT-IR gas analyzer. In accordance with new Claim 25, the apparatus employed for monitoring the combustion process must also be capable of measuring the concentration of molecular hydrogen, and the method does so concurrently with measurement of molecular oxygen and the infrared-active component. Claims 26 and 27 define the preferred position of the oxygen sensor (not only within the product case, but also downstream of the gas sample cell), which is particularly important when the sensor is heated (typically to 600° C) so as to avoid causing degradation or other compositional changes, and especially so when the sample contains reactive hydrocarbons.

### *The Rejections*

All claims of the application stand rejected as having been anticipated by Kameoka U.S. Publication 20030184733 A1, or as having been obvious to one of

ordinary skill in the art over the same reference taken in combination with Nishizawa et al. U.S. patent No. 4,859,307. Irrespective of any merit that may have existed in the rejections of the claims originally presented in this application, certainly the instant amended claims define an invention that is novel and nonobvious over the prior art.

Kameoka discloses a combined analyzing apparatus that necessarily includes a front-end unit, an FTIR, a mass separation unit (MS), and a battery (and a pump [0063]), all housed within a portable case. The front-end unit, the FTIR, and the MS must each take the gas sample inside, for analysis.

As is clear from paragraphs [0005] and [0006] of the specification, Kameoka seeks to provide means for making on-site measurements of toxic gases to respond to terrorism attacks and crimes using chemical weapons, and for enabling immediate on-site analysis for gaseous global environmental pollutants. In contrast to the present invention, Kameoka evidences no interest in providing apparatus for monitoring combustion processes, so as to determine concentrations of molecular oxygen (in particular) and molecular hydrogen, and the reference teaches nothing that would promote that capability; obviously, molecular oxygen and hydrogen are not toxic gases or pollutants.

It is perfectly obvious that Kameoka has no appreciation for the desirability of integrating any sensor or other analysis unit into an FT-IR product case so as to provide a compact system, in which overall product dimensions are not increased, as is uniquely provided by the apparatus of the present invention. It is even more obvious that the Kameoka apparatus *necessarily* includes analysis units that could not possibly be enclosed within any conventional FT-IR product case. In paragraph [0002], for example, Kameoka characterizes the combined apparatus as “using a light analyzing apparatus and a mass analyzing apparatus,” and in paragraph [0008] he states that the apparatus is “a combination of *at least* a light analyzing apparatus and a mass analyzing apparatus” (emphasis added), including the necessary ionization and detection units, and a pump. Thus, Kameoka teaches against a

fundamental and functionally essential requirement of the instant claims, i.e., that the analysis apparatus be devoid of gas analysis means disposed external to an FT-IR product case.

The portable case 50 of the Kameoka apparatus is of course much larger than that which would be appropriate for the containment of the FT-IR components, as it must be in order to accommodate the mass spectrometer 20, the front end unit 30, and the battery 40 (see in particular Figures 1 and 5). Moreover, the case 50 does not *enclose* therewithin any of the system components. Rather, it comprises an open housing 51 to which a lid 52 is hingedly attached to enable it to open and close flexibly.

In the interest of packing disparate units into a common portable case, each of which units would affect the temperature of the others, Kameoka compromises the thermal stability and equilibrium of the three separate instruments and, in turn, may well compromise the quality, reliability and accuracy of the quantitative measurements that can be made using the apparatus. As is well known to those skilled in the art, interferometer and detector performance, optical alignments, source temperatures, and electronics can all be affected by variations in thermal conditions, and it is conventional therefore to enclose FT-IR instruments within suitable product cases, thereby protecting the components and the gas flow conduits against external temperature influences.

The arrangement claimed by Applicants not only enables minimization of the size and weight of the analysis apparatus provided (the sensors make only a negligible contribution to the size and the weight of the apparatus, as disclosed in the paragraph beginning at line 3 on page 8 of the specification), while providing a common enclosure, but it also enables close coupling of the oxygen and hydrogen measuring devices with the FT-IR optical cell, thereby ensuring that concurrent measurements are made from identical gas samples and in turn affording utmost accuracy (see the paragraph bridging pages 3 and 4 of the specification). The sensors employed afford suitable response times, relative to that of the FT-IR spec-

trometer, and (unlike the supplemental units disclosed by Kameoka) they maintain the gas flow unimpeded. Moreover, the integrated configuration of Applicants' apparatus enables the use of a single power supply for all internal electronics and integrated sensors, permitting data signals from the FT-IR sensor and integrated sensors to be digitally processed within the FT-IR product case before being output to a data processing unit, and permitting the use of a common, central electrical ground; these factors, in turn, tend to minimize electronic noise and interference.

With respect to Claims 5-9 and 16-20, the Examiner asserts in the Office Action that it would have been obvious to modify Kameoka to include the gas sensor of Nishizawa. To the contrary, it clearly would *not* have been obvious to employ in the Kameoka apparatus any sensor for detecting and measuring oxygen, as is now an essential feature of Applicants' apparatus and method.

First of all, and as noted above, Kameoka has no interest in, and provides no teaching pertinent to, the analysis of a gas sample to measure its molecular oxygen (or hydrogen) concentration. Thus, the proposed combination lacks fundamentally the motivation in the art that is required for a proper combination of references, and is arrived at by the Examiner only through hindsight reliance upon Applicants' own disclosure.

Moreover, even if Kameoka did wish to measure the concentration of oxygen (and/or hydrogen), it is well known in the art that a mass separation unit inherently has that capability. Therefore, there would again be no proper motivation, or justification, for substituting any sensor disclosed by Nishizawa into the Kameoka apparatus. And once again, Kameoka deems a mass separation unit to be essential in his apparatus.

Furthermore, the only homonuclear diatomic gas disclosed by Kameoka is chlorine. Kameoka has no concern that such gases are infrared-inactive and, moreover, chlorine would poison the sensors employed by Applicants for the

measurement of molecular oxygen (and hydrogen). One skilled in the art would certainly not employ them in the Kameoka apparatus.

The unique method defined by new Claims 23-25 is clearly novel and nonobvious over the prior art. In addition to deriving the benefits afforded by close coupling of the oxygen (and hydrogen) sensor, as described above (and especially in the preferred position recited in Claim 27), immediate dynamic and comprehensive monitoring of any selected combustion process is readily afforded. Such a method is nowhere taught in or suggested by the prior art.

Thus it is respectfully submitted that the instant claims define an apparatus and method that are entirely novel and patentable over the art. Passage of the application to allowance is believed to be clearly in order, and such action is earnestly solicited.

Enclosed is a Petition for a One-Month Extension of Time, together with PTO Form 2038 authorizing a charge in the amount of the required fee (\$60). The form also includes an amount (\$75) in payment of the fee for the presentation of three additional claims in excess of 20.

If the amount of any fee authorized is insufficient, please charge the deficiency to Deposit Account No. 502982.

Respectfully submitted,  
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CERTIFICATE OF MAILING

I, IRA S. DORMAN, hereby certify that this correspondence is being deposited with the United States Postal Service as First Class Mail, in an envelope addressed as set forth on the first page hereof, on June 21, 2006.

A handwritten signature in black ink, appearing to be "Ira S. Dorman", written over a horizontal line.

cc: Mr. James R. Markham